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Geometric Filtering of Shapes in Real-Time

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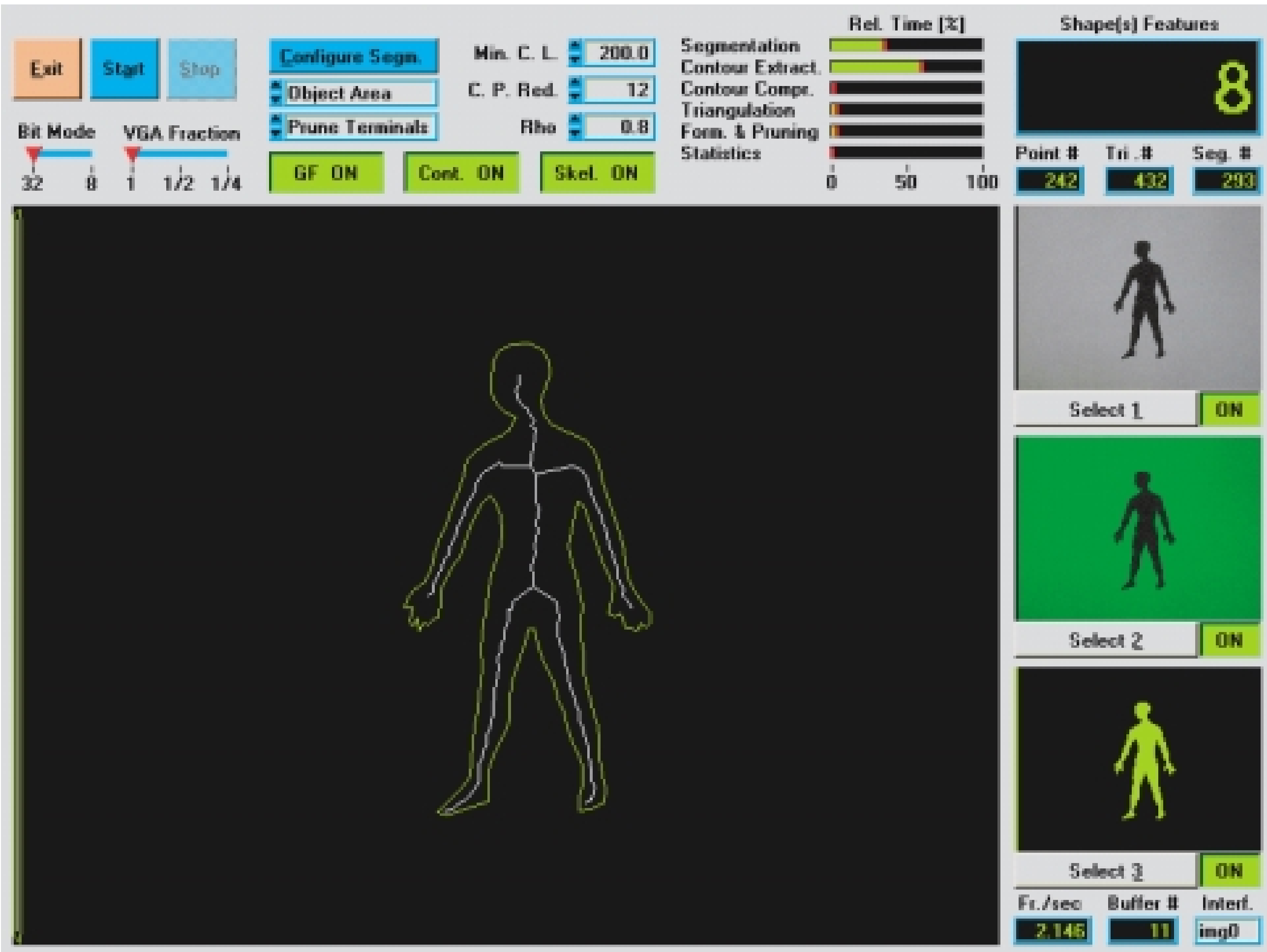
The key to the information contained in images lies in the ability to identify objects, features, and their interrelationships. A new technique [1, 2, 3] to extract such relevant features of shapes in images was introduced recently. During the last year we have successfully implemented the necessary computer vision code for this geometric filtering of shapes. and a personal computer with 600-MHz Intel Pentium III processor. Our software consists of ANSI-C computer vision code [4], which is embedded into National Instruments measurement software LabWindows/CVI. The graphical user interface (GUI) of our geometric filtering software is shown in the figure.



Our computer vision system consists of a Sony EVI-G20 video camera (NTSC), a National Instruments PCI-1411 color video frame grabber card (max. 30 frames/second), We can either process true color images (32-bit mode) or grey level images (8-bit mode) coming from the streaming video. The original images displayed in the

"Select 1" window. In case of true-color mode we process for convenience here only the green part of the RGB images (shown in the "Select 2" window). A spectral interval selection in the pixel value histograms of either the grey or green level images allows us to obtain shape segments or image blobs of interest ("Select 3" window).

Image blobs are processed as follows. First the blobs are enclosed with dilated contours [5]. Then the contour point set and the generated contour edges form the input to a constrained Delaunay tessellation. The subsequently applied Chordal Axis Transform (CAT) [1, 2, 3] provides a morphological decomposition of the shapes into simplical chain complexes of shape features (limbs and torsos). Our geometric filtering procedure allows also for the pruning of morphologically insignificant shape features. The dilated contours and the final CAT skeleton are displayed in the main screen of the GUI, respectively. The number of the shapes features is displayed in the upper right corner of the GUI. In addition, we compute the statistical features such as areas, width, lengths, etc., of all shape features without displaying them explicitly.

While we acquire the images and perform our geometric filtering, we measure the performance of our software. The processing time depends heavily on the size of the image array, color vs. grey level images, and the number of image blobs under consideration. The presented example of a human shape gives us a processing rate of about 2 images (frames) per second. Image segmentation and contour extraction alone require about 90% of the processing time. Since these algorithms are cellular (i.e., operate at the pixel level) significant speedup can be achieved by implementing these algorithms in firmware (e.g., FPGAs: field programmable gate arrays). Our software could then be accelerated by at least a factor ~ 10, which would yield image processing rates of 20 frames/second for true color images with the video graphics array resolution (640 x 480 pixels). Further speedup towards real-time geometric filtering, i.e., 30 frames/second could be possible by using a faster CPU with preferably a vector architecture.

Eventually, the shape features and their attributes will be passed onto a shape encoding mechanism, which will allow to recognize shapes within a special purpose database. The computer algorithms which will perform these tasks are currently being implemented by us here at Los Alamos National Laboratory.

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[1] L. Prasad, "Morphological Analysis of Shapes," *CNLS Newsletter*, No. 139, July '97, LALP-97-010-139, Center for Nonlinear Studies, Los Alamos National Laboratory.

[2] L. Prasad, R. Rao, "Morphological Analysis of Shapes," in *Special Feature, Supplement to the T-Division Self-Assessment for 1997/1998*, Los Alamos, May 1998, LA-UR-98-1150, p. 107.

[3] L. Prasad, R. L. Rao, "A geometric transform for shape feature extraction," Proceedings of SPIE's 45th Annual Meeting, San Diego, CA, Vol. 4117 (2000) 222.

[4] B. R. Schlei, L. Prasad, "Code Implementation for Morphological Analysis of Shapes," *Special Feature.2000, Supplement to the T-Division Self-Assessment for 1999/2000*, Los Alamos, April 2000, LA-UR-00-1, p. 3.

[5] B. R. Schlei, L. Prasad, "A Parallel Algorithm for Dilated Contour Extraction from Bilevel Images," Los Alamos Preprint LA-UR-00-309, cs.CV/0001024.

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